605 Steel Structures
606 Metal Bridge Railing
607 Removal of Existing Concrete and Masonry
608 Coarse Aggregate for Foundation Stabilization and Subfoundation Backfill
609 Subfoundation Concrete
610 Stone Masonry
611 Brick Masonry
612 Reinforced Concrete Pipe
614 Corrugated Pipe
617 Flared End Section
618 Pile Materials
619 Installation of Piles

605.40 Method of Measurement. The quantity of steel structures will not be measured if payment is on a lump sum basis. If payment is based on the Contract unit price per pound (kilogram), then the quantity of steel structures will be measured in pounds (kilograms). Unless measurement by the scale weight is specified, the quantity of steel will be computed on the following basis:

a. Unit weights, lb/ft; (kg/m;)

Aluminum, cast or wrought	173 (2770)
Bronze, cast	536 (8590)
Copper-alloy	536 (8590)
Copper sheet	558 (8940)
Iron, cast	445 (7130)
Iron, malleable	470 (7530)
Iron, wrought	487 (7800)
Lead, sheet	707 (11 330)
Steel, rolled, cast, copper bearings, silicon, nickel, and stainless	490 (7850)
Zinc	450 (7210)

b. The weights of rolled shapes shall be computed on the basis of their nominal weights per foot (meter) as shown on the drawings, or listed in the AISC Manual of Steel Construction.

   The weights of plates shall be computed on the basis of the nominal weight of their width and thickness, as shown in the drawings, plus an estimated over-run computed as one-half the permissible variation in thickness and weight as tabulated in AASHTO M 160/M 160M.

c. The weight of castings shall be computed from the dimensions shown on the approved shop drawings, deducting for open holes. To this weight shall be added 5% allowance for fillets and overruns. Scale weights may be substituted for computed weights in the case of castings or of small complex parts for which accurate computations of weight would be difficult.

d. The weight of temporary erection bolts; shop and field paint; boxes, crates, and other containers used for shipping; and materials used for supporting members during transportation and erection shall not be included.

e. When computing the pay weight on the basis of computed net weight the following stipulations in addition to those in (a) through (d) above shall apply:

1. The weight shall be computed on the basis of the net finished dimensions of the members as shown on the approved shop drawings, deducting for copes, cuts, clips, and all open holes.

2. The aggregate weight of heads, nuts, single washers, and the threaded stick-through of all high strength shop bolts shall be included on the basis of the following weights:

Table 605F

U.S. Customary

Diameter of Bolt Inches	Weights per 100 Bolts, pounds
1/2	19.7
5/8	31.7
3/4	52.4
7/8	80.4
1	116.7
1 1/8	165.1
1 1/4	212.0
1 3/8	280.0
1 1/2	340.0

Table 605-F
Weights of Metric High-Strength Structural Bolts [1]
approximate weight of 100 steel bolts in kilograms

Bolt Length (mm)	*Nominal Bolt Diameter and Thread Pitch*						
	M16 H 2	*M20 H 2.5*	*M22 H 2.5*	*M24 H 3*	*M27 H 3*	*M30 H 3.5*	*M36 H 4*
45	10.8	---	---	---	---	---	---
50	11.6	19.8	---	---	---	---	---
55	12.3	21.0	26.0	---	---	---	---
60	13.1	22.3	27.5	35.4	---	---	---
65	13.9	23.5	29.0	37.1	50.5	---	---
70	14.7	24.7	30.5	38.9	52.7	64.0	---
75	15.5	26.0	32.0	40.7	55.0	66.8	---
80	16.3	27.2	33.5	42.4	57.2	69.6	108
85	17.1	28.4	34.9	44.2	59.5	72.4	112
90	17.9	29.7	36.4	46.0	61.7	75.1	116
95	18.6	30.9	37.9	47.8	63.9	77.9	120
100	19.4	32.1	39.4	49.5	66.2	80.1	124
110	20.8	34.3	42.1	52.7	70.4	85.6	132
120	22.4	36.8	45.0	56.2	74.9	91.1	140
130	24.0	39.2	48.0	59.7	79.4	96.7	148
140	25.6	41.7	51.0	63.3	83.9	102	155
150	27.1	44.1	54.0	66.8	88.4	108	163
160	28.7	46.6	57.0	70.4	92.8	113	171
170	30.3	49.1	59.9	73.9	97.3	119	179
180	31.8	51.5	62.9	77.5	102	124	187
190	33.4	54.0	65.9	81.0	106	130	195
200	35.0	56.4	68.9	84.6	111	135	203
210	36.6	58.9	71.8	88.1	115	141	211
220	38.2	61.4	74.8	91.6	120	146	219
230	39.7	63.8	77.8	95.2	124	152	227

240	41.3	66.2	80.8	98.7	129	158	235
250	42.9	68.7	83.8	102	133	163	243
260	44.5	71.2	86.7	106	138	169	251
270	46.0	73.7	89.7	109	142	174	259
280	47.6	76.1	92.7	113	147	180	267
290	49.2	78.6	95.7	116	151	185	275
300	50.8	81.1	98.6	120	156	191	283

Note 1: From ANSI B18.2.3.7M, Table 3.

3. The weight of weld metal shall be computed on the basis of the theoretical volume from dimensions of the welds.

f. When computing the pay weight on the basis of scale weight, the pay quantity of structural steel will be the shop scale weight of the fabricated members, weighed on satisfactory scales in the presence of the inspector. If the shop paint has been applied to the completed member when weighed, 0.4% of the weight of the member shall be deducted from the scale weight to compensate for the weight of shop paint.

The quantity of recoating will either be measured by the square foot (square meter) of area recoated or will not be measured.

605.41 Basis of Payment.

a. *Steel.* The quantity of steel structures will be paid for either at the Contract unit price per pound (kilogram) or on a lump sum basis. Price and payment will constitute full compensation for all labor, materials, equipment, and transportation required for furnishing, fabricating, transporting, erecting, and shop and field painting to complete the work. The quantity of recoating will be paid for either at the Contract unit price per square foot (square meter) or at the Contract lump sum price.

The Contract price for steel structures shall also include, when applicable, taking field elevations along the tops of the existing beams; removal of existing blast plates; and modifications to existing beams for widening except those specifically paid for under the applicable Section. Also included are all additional costs for stage construction for all the work on the Project. The cost of painting of all new structural steel includes all material, labor, tools and equipment, and surface preparation, spatter protection, and cleanup.

When tests of fabricated members are required by the Contract, the cost of testing, including equipment, handling, supervision, and incidentals including but not limited to temperature indicating crayons, liquids, or bimetal thermometers for making the test, will be included in the Contract unit price per pound (kilogram) of structural steel, unless otherwise specified.

All metal parts such as anchor bolts and nuts, shoes, rockers, rollers, bearing and slab plates, pins and pilot and driving nuts, expansion dams, roadway drains and scuppers, weld metal, bolts embedded in concrete, cradles and brackets, blast plates, and waterstops shall be paid for as structural steel unless otherwise stipulated. Steel reinforcement for concrete is not included in this Section and will be paid separately under the appropriate Section.

Payment will be made on a lump sum or price per pound (kilogram) basis as required by the terms of the Contract. When payment is to be based on price per pound (kilogram), the finished work shall be weighed in the presence of the inspector, if practicable. The Contractor shall supply satisfactory scales and shall perform all work involved in handling and weighing the various members.

If payment is made on a lump sum basis the Contractor should note that the approximate weight of structural steel is stated in the proposal. It shall be the responsibility of the Contractor, however, to estimate and

determine for itself the amount of metal work required as the quantity given is not guaranteed to be absolutely correct.

If payment is made on a price per pound (kilogram) basis, the payment shall be based on the computed net weight of metal in the fabricated and erected structures unless the Contract provides that payment shall be based on the scale weight. No payment will be made for any weight in excess of 1.5% above the computed net weight of the whole item.

b. *Painting.* The quantity of recoating all existing structural steel, unless specified elsewhere, will be paid for at the Contract unit price per square foot (square meter) or lump sum price. Price and payment will constitute full compensation for all material, labor, tools and equipment, surface preparation, spatter protection, and cleanup.

Price and payment for the moisture-cured urethane paint system will constitute full compensation for furnishing all materials; for providing protection against damage during paint application; for re-establishing Project standards, if necessary; for re-cleaning when primer is not applied within eight hours of initial cleaning; for re-cleaning and repainting surfaces when unauthorized solvents are used, when paint containing thinners is applied, when paint is applied to contaminated surfaces, and when paint is applied contrary to the requirements of this Section; and for all labor, equipment, tools, and incidentals required to complete the work.

Progress payments will be made based on the percentage of the structure primed and painted with two full coats of paint in accordance with the specification. The percentage will be computed as the ratio of the length of structure primed to the total length of structure. The percentage of payments to be paid to the Contractor will be 25%, 50%, 75%, and 100% after the completion of the work.

SECTION 606 METAL BRIDGE RAILING

606.01 Description. This work consists of furnishing, fabricating, and erecting either aluminum bridge railing or galvanized steel bridge railing.

606.02 Materials. Materials shall be as specified on the Plans. If galvanized steel is used, it shall be galvanized after fabrication.

606.03 Construction Methods. The type of rail and details shall be as shown on the Plans. Each post base shall be set on a preformed elastomeric pad, conforming to the requirements of Subsection 826.06. The outline of the pad shall conform to the base of the post or base plate. All posts shall be set normal to grade, and all rails shall be set parallel to grade. Anchor bolts shall be set prior to pouring the concrete and shall be firmly held in place by a template. The portions of anchor bolts exposed above the concrete shall be given a protective coating of grease or oil before the concrete is poured.

All rough or sharp corners which, in the opinion of the Engineer, would endanger pedestrians shall be ground smooth either during fabrication or after erection. All anchor bolts and other connecting bolts and fasteners shall be burred to prevent loosening after erection is completed.

No paint will be required on the completed installation except for any touch up of damaged coating. Such damaged areas shall be coated with a material acceptable to the Engineer. Before acceptance of the installation, the railing shall be thoroughly cleaned of all dirt, grime, and stains. Cleaning methods and agents shall be used in accordance with the recommendations of the rail manufacturer.

606.04 Method of Measurement. The quantity of metal bridge railing will be measured as the actual number of linear feet (linear meters) of railing sections, installed and accepted.

606.05 Basis of Payment. The quantity of metal bridge railing will be paid for at the Contract unit price per linear foot (linear meter). Price and payment will constitute full compensation for furnishing, fabricating, and installing all materials; for touch up of damaged coatings; and for all labor, equipment, tools, and incidentals required to complete the work.

SECTION 607 REMOVAL OF EXISTING CONCRETE AND MASONRY

607.01 Description. This work consists of the removal and acceptable disposal of existing rubble, concrete, and masonry that interferes with the completion of new construction except such objects as are designated to remain or are to be removed in accordance with other Sections of these Specifications.

607.02 Construction Methods. Care shall be used during the removal of existing concrete and masonry to avoid damage to existing concrete and masonry construction that is to remain in place.

607.03 Method of Measurement. The quantity of existing concrete and masonry removed will be measured by the cubic yard (cubic meter) based on computations using field measurements of the concrete and masonry in place prior to removal.

607.04 Basis of Payment. The quantity of existing concrete and masonry removed will be paid for at the Contract unit price per cubic yard (cubic meter). Price and payment will constitute full compensation for the removal and disposal of the existing rubble, concrete, and masonry and for all labor, equipment, tools, and incidentals required to complete the work.

SECTION 608 COARSE AGGREGATE FOR FOUNDATION STABILIZATION AND SUBFOUNDATION BACKFILL

608.01 Description. This work consists of furnishing and placing coarse aggregate for foundation stabilization and subfoundation backfill. This Section is to be used only when specified and authorized by the Engineer.

608.02 Materials. Coarse aggregate shall conform to the provisions of Section 805 and to the grading requirements of Section 813, Delaware No. 57.

608.03 Construction Methods. The bedding areas on which the coarse aggregate is to be placed will be approved by the Engineer.

Coarse aggregate shall be carefully placed and tamped to form a solid, unyielding mass with the exposed surface conforming to the form and dimensions shown on the Plans. Coarse aggregate shall be placed in locations where the exposed soil conditions are of such a nature and composition as to require the use of this material to achieve a satisfactory load-bearing condition.

608.04 Method of Measurement. The quantity of coarse aggregate will be measured as the actual weight placed and accepted. The weight will be calculated as specified in Subsection 109.01.

608.05 Basis of Payment. The quantity of coarse aggregate will be paid for at the Contract unit price per ton (metric ton). Price and payment will constitute full compensation for furnishing, hauling, and placing the material and for all equipment, tools, labor, and incidentals required to complete the work.

SECTION 609 SUBFOUNDATION CONCRETE

609.01 Description. This work consists of placing Portland cement concrete to level rock foundations, seal rock fissures, and for other similar purposes. This Section is to be used only when specified and authorized by the Engineer.

609.02 Materials. Portland cement concrete shall conform to the requirements of Section 812, Class C.

609.03 Construction Methods. Subfoundation concrete shall not be reinforced and need not be vibrated.

Unless otherwise ordered, curing requirements for subfoundation concrete may be reduced to three days.

609.04 Method of Measurement. The quantity of subfoundation concrete will be measured as the number of cubic yards (cubic meters) of subfoundation concrete placed and accepted. When limits are shown on the Plans, they shall govern for payment purposes. All costs for required forming will be included under this work. When the limits are not shown on the Plans, prior to the work the Engineer will take cross-sections of the spaces to be filled with subfoundation concrete and will compute the volume by the average end area method.

609.05 Basis of Payment. The quantity of subfoundation concrete will be paid for at the Contract unit price per cubic yard (cubic meter). Price and payment will constitute full compensation for furnishing and placing all materials; for required forming; and for all labor, tools, equipment, and incidentals required to complete the work.

SECTION 610 STONE MASONRY

610.01 Description. This work consists of furnishing all materials for and constructing stone masonry.

MATERIALS.

610.02 Portland Cement. Portland cement shall conform to the requirements of Section 801.

610.03 Fine Aggregate. Fine aggregate shall conform to the requirements of Section 818.

610.04 Water. Water shall conform to the requirements of Section 803.

610.05 Hydrated Lime. Hydrated lime shall conform to the requirements of Section 802.

610.06 Stone. Stone shall be of the dimensions and type as detailed and specified on the Plans. The Contractor shall submit samples of stone for approval prior to starting in case of new masonry work. Materials for masonry repair/replacement shall match the existing stone and patterns.

610.07 Steel Wall Ties. All steel wall ties shall be hot-dipped galvanized.

CONSTRUCTION METHODS.

610.08 Excavation. Excavation shall be made to the required depth when necessary, to expose the foundation on which stone masonry is to be placed.

610.09 Mortar. Portland cement mortar shall be mixed in the proportion of one part Portland cement to three parts fine aggregate, to which shall be added hydrated lime not to exceed 10% of the cement by weight. The fine aggregate, Portland cement, and lime shall first be mixed dry in an approved manner until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains such consistency as can be easily handled and spread with a trowel. The mortar shall be so placed to form a firm bond. Mortar which is not used within 30 minutes after water has been added shall be wasted. Re-tempering of mortar will not be permitted.

610.10 Placing Stone. All masonry work shall be constructed by experienced stone masons. The stone shall be laid to the wall to form the pattern shown on the Plans, and shall be thoroughly wetted before laying in mortar. All joints shall be completely filled with mortar and shall be finished properly as work progresses. Mortar joints shall be 1" (25 mm) to 1$\frac{1}{2}$" (38 mm) thick.

No masonry shall be laid in freezing weather.

610.11 Cleaning. After constructing the stone masonry, the entire area shall be thoroughly cleaned of all mortar, scars, or spots. Efflorescence may be partly removed by water, but where special treatment is necessary, the area shall be first washed down with water, then treated with a solution of three parts hydrochloric acid to 100 parts of water following washing with water again. The Contractor shall be watchful to notice for any deteriorating reaction to the stone masonry, and in such case the treatment shall stop, and the treated area shall be thoroughly washed down with water. However, it shall be the responsibility of the Contractor to clean the constructed masonry as to present a natural color.

610.12 Backfilling. The excavated areas which are not occupied by the stone masonry shall be backfilled to the required elevation with suitable material which shall be tamped in layers of not more than 6" (150 mm), until firm and solid. No backfill shall be made prior to approval.

610.13 Method of Measurement. The quantity of stone masonry placed and accepted will be measured by the square foot (square meter).

610.14 Basis of Payment. The quantity of stone masonry will be paid for at the Contract unit price per square foot (square meter). Price and payment will constitute full compensation for excavating and backfilling; for furnishing and placing all materials; for the disposal of surplus materials, and for all labor, equipment, tools, and incidentals required to complete the work, including cleaning.

SECTION 611 BRICK MASONRY

611.01 Description. This work consists of constructing brick masonry.

MATERIALS.

611.02 Portland Cement. Portland cement shall conform to the requirements of Section 801.

611.03 Fine Aggregate. Fine aggregate shall conform to the requirements of Section 818.

611.04 Water. Water shall conform to the requirements of Section 803.

611.05 Hydrated Lime. Hydrated lime shall conform to the requirements of Section 802.

611.06 Brick. Brick shall be new, whole brick of best quality, of uniform and dense structure, free from lumps of lime, laminations, cracks, checks, soluble salt, or other defects that in any way impair their strength, durability, appearance, or usefulness for the purpose intended. All brick shall conform to requirements of AASHTO M 114 for Grade SW brick. The Contractor must submit samples for approval when the masonry is exposed to general view.

CONSTRUCTION METHODS.

611.07 Excavation. Excavation shall be made to the required depth when necessary, to expose the existing foundation on which the brick masonry is to be placed.

611.08 Mixing Mortar. Portland cement mortar shall be mixed in the proportion of one part Portland cement to three parts fine aggregate, to which shall be added hydrated lime not to exceed 10% of the cement by weight. The fine aggregate, Portland cement, and lime shall first be mixed dry in an approved manner until the mixture assumes a uniform color, after which water shall be added as the mixing continues until the mortar attains such consistency as can be easily handled and spread with a trowel. The mortar shall be so placed to form a firm bond. Mortar that is not used within 30 minutes after water has been added shall be wasted. Re-tempering of mortar will not be permitted.

611.09 Placing Bricks. Bricks shall be laid by means of the shove-joint method so as to thoroughly bed them into the mortar. Buttered or plastered joints will not be permitted. All brick headers and stretchers shall be so arranged as to thoroughly bond the mass with alternate courses breaking joints. All joints shall be completely filled with mortar and shall be finished properly as the work progresses. Joints shall be not less than 3" (6 mm) and not more than 2" (13 mm) in thickness. No spalls or bats shall be used except for shaping irregular openings or when unavoidable to finish out a course, in which case, full bricks shall be placed at the corners and bats shall be placed in the interior of the course. Competent bricklayers shall be employed on work of this class.

611.10 Cleaning. Brick masonry which is to be exposed after completion of the structure, shall be thoroughly cleaned of all mortar, scars, or spots, and shall present a surface showing the natural color of the bricks. Efflorescence may be partly removed by water. The wall shall be first washed down with water, then treated with a solution of three parts hydrochloric acid to 100 parts of water, and finally washed thoroughly again with water.

611.11 Backfilling. The excavated areas which are not occupied by the brick masonry shall be backfilled to the required elevation with suitable material which shall be tamped in layers of not more than 6" (150 mm), until firm and solid. No backfill shall be made prior to approval.

611.12 Method of Measurement. The quantity of brick masonry placed and accepted will be measured by the square foot (square meter).

611.13 Basis of Payment. The quantity of brick masonry will be paid for at the Contract per square foot (square meter). Price and payment will constitute full compensation for excavating and backfilling; for furnishing and placing all materials; for the disposal of surplus materials; and for all labor, equipment, tools, and incidentals required to complete the work, including cleaning.

SECTION 612 REINFORCED CONCRETE PIPE

612.01 Description. This work consists of furnishing and installing reinforced concrete round or elliptical pipe. This work also includes the construction of connections to existing drainage inlets and manholes as may be required to complete the work.

MATERIALS.

612.02 Reinforced Concrete Pipe.

a. *Round Pipe.* Reinforced concrete round pipe shall conform to the requirements of AASHTO M170 (M 170M) and shall be Class III unless otherwise noted.

b. *Elliptical Pipe.* Pipe designed for placement with the major axis horizontal shall be designated as horizontal elliptical pipe (HE). Pipe designed for placement with the major axis vertical shall be designated as vertical elliptical pipe (VE).

   Reinforced concrete elliptical pipe shall conform to the requirements of AASHTO M207 (M 207M) and the following:

   1. Standard strength reinforcement concrete elliptical pipe (HE or VE) shall be Class III.

   2. Extra strength reinforced concrete elliptical pipe (HE or VE) shall be Class IV.

No pipe shall be shipped from the plant to the Project until the requirements of AASHTO M170 (M 170M) or M207 (M 207M) are met and the pipe is marked with the Department's inspection stamp. The manufacturer shall have clearly marked on the pipe the following information before inspection is made:

1. Pipe class
2. Pipe type, HE or VE, for elliptical pipe only
3. Date of manufacture
4. Name or trademark of the manufacturer
5. One end of each section of elliptical pipe shall be clearly marked, during the process of manufacture or immediately thereafter, on the inside and the outside of the opposite walls along the minor axis.

All pipe inspected and approved at the manufacturing plant shall be subject to inspection at the site of the work, and no previous stamp or approval shall bar rejection if the pipe is found to be defective or damaged.

612.03 Joint Material. A rubber gasket conforming to the requirements of AASHTO M 315 (M 315 M) shall be used to seal the joints between successive sections of pipe.

612.04 Backfill Material. Backfill material shall conform to the requirements of Subsection 209.04, Borrow Type C. If the existing material meets these requirements, it shall be used for pipe backfill.

CONSTRUCTION METHODS.

612.05 Excavation. The trench in which the pipe is laid shall be excavated in accordance with Section 208 to the required depth. The bottom of the trench shall be shaped to provide the required class of bedding. Where rock is encountered, the trench shall be excavated in depth to the bottom of the earth cushion as shown on the Standard Construction Details for bedding in rock, and for a width of 12" (300 mm) on each side of the pipe. This depth and width shall be backfilled with approved material and thoroughly tamped.

612.06 Bedding of Pipe. Unless noted otherwise, all pipes shall receive a Class C bedding. Class C bedding shall consist of bedding the pipe in a trench carefully shaped to conform to the outside circumference of the pipe for a depth not less than 10% of the outside diameter of the pipe. Shaping of the bed to conform to the shape of the pipe at joints shall also be required.

612.07 Joints. Before laying the pipe in the trench, the rubber gasket shall be attached to the spigot end of each pipe joint and set firmly against the shoulder around the entire circumference of the pipe joint. A lubricant, specified by the gasket manufacturer, may be applied to the gasket for ease of installation.

Pipe handling after the gasket has been affixed shall be carefully controlled to avoid bumping the gasket and thus displacing it or covering it with dirt or other foreign material. Any gasket so disturbed shall be removed, replaced if damaged, and repositioned if displaced. Sufficient pressure shall be applied in making the joint to ensure that the joint is tight.

612.08 Laying Pipe. All pipe shall be laid in an upgrade direction unless otherwise directed. The pipe shall be laid with the lowest point of the inside diameter conforming with the flow line shown on the Plans.

All pipe shall be carefully laid with the bell ends upgrade, with the spigot ends fully entered into the adjoining bell, and true to the lines and grades shown on the Plans, or as directed.

Any pipe which is not in true alignment, or which shows any settlement after laying, shall be taken up and re-laid. Unsuitable material encountered below the flow line of pipe shall be removed to a depth and replaced, as directed.

612.09 Backfill. Placement of backfill shall conform to Section 208. Where heavy construction equipment travels over the pipe, a cover of material shall be placed to a minimum depth of 4' (1.2 m)

612.10 Method of Measurement. The quantity of reinforced concrete round or elliptical pipe will be measured as the actual number of linear feet (linear meters) of each type of pipe placed and accepted, measured from end to end of pipe, including structure wall thickness, but excluding structure interior.

612.11 Basis of Payment. The quantity of reinforced concrete round or elliptical pipe will be paid for at the Contract unit price per linear foot (linear meter) for each type of pipe. Price and payment will constitute full compensation for furnishing, hauling, and installing pipe; for all cribbing or foundation treatment necessary to prevent settlement; for all shoring and sheeting; for the replacement of any pipe which is not true in alignment or which shows any settlement after laying; and for all material, labor, equipment, tools, and incidentals required to complete the work.

For round pipe under 24" (600 mm) nominal inside diameter, and elliptical pipe under 24" (600 mm) nominal inside horizontal dimension, the excavation (excluding rock), backfill, and backfilling will be included in the price for this work. For pipe of nominal inside diameter or horizontal dimension of 24" (600 mm) and over, payment for excavation and backfill will be in accordance with Section 208. Furnishing of Borrow Type C for pipe of nominal inside diameter or horizontal dimension of 24" (600 mm) and over, will be paid for under Section 210.

Payment for excavation and replacement of unsuitable material encountered below the flow line of pipe will be provided for under Section 208.

SECTION 613 RESERVED

SECTION 614 CORRUGATED PIPE

614.01 Description. This work consists of furnishing and installing corrugated aluminum pipe. This work also includes the furnishing and construction of joints and connections to existing pipes, drainage inlets, and end-walls, as may be required to complete the work as indicated on the Plans, or as directed.

MATERIALS.

614.02 Pipe.

a. *Corrugated Steel Pipe.* Corrugated steel pipe shall conform to the requirements of AASHTO M 36/M 36M.

    1. Zinc-coated (galvanized) corrugated steel pipe shall conform to AASHTO M 218.
    2. Aluminum-coated (Type 2) corrugated steel pipe shall conform to AASHTO M 274.

b. *Corrugated Aluminum Pipe.* Corrugated aluminum pipe shall conform to the requirements of AASHTO M 196/M 196M.

c. *Spiral Rib Pipe.* Spiral rib pipe (Type 1R) shall conform to the requirements of AASHTO M 36/M 36M for steel spiral rib and to AASHTO M 196/M 196M for aluminum spiral rib pipe.

614.03 Bituminous Coating. When bituminous coating is called for, it shall conform to the requirements of AASHTO M 190.

614.04 Bands. All corrugated steel or corrugated aluminum pipe shall be furnished in lengths specified on the Plans. If any specified length of pipe is divided into shorter sections for convenience, approved connecting bands shall be furnished for field joints. The coupling bands shall conform to AASHTO M 36/M 36M.

Bands shall be constructed so as to lap an equal portion of each of the pipe sections to be connected. Bands shall be fastened at the ends by galvanized angles having minimum dimensions of 2 by 2 by 3/16'' (50 by 50 by 4.75 mm). Other equally effective methods of fastening the bands may be used if approved. All bands shall include an approved rubber gasket to ensure a watertight joint.

Connecting bands used under this Section shall not be bituminous coated.

614.05 Defects. The following defects in corrugated steel or corrugated aluminum pipe constitute poor workmanship, and the presence of any of them in any individual pipe shall be sufficient cause for rejection:

a. Uneven laps
b. Elliptical shaping (circular pipe only)
c. Variation from a straight centerline
d. Ragged or diagonal sheared edges
e. Loose, unevenly lined or spaced rivets
f. Imperfectly formed rivet heads
g. Unfinished ends
h. Illegible brand
i. Lack of rigidity
j. Bruised, scaled, or broken protective coating
k. Dents or bends in the metal

614.06 Field Inspection. Field inspections will be made and will include an examination of the pipe for deficiencies in lengths of sheet used, thickness of metal, nominal inside diameter, net length of finished pipe, and any evidence of poor workmanship as outlined in this Section. The inspection may include the taking of samples for chemical analysis and determination of coating thickness and quality.

614.07 Backfill Material. Backfill material shall conform to the requirements of Subsection 209.04, Borrow Type C. If the existing material meets these requirements, it shall be used for pipe backfill.

CONSTRUCTION METHODS.

614.08 Pipe Installation. All pipe shall be carefully handled during unloading and placing in position. Dragging the pipe over the ground or over timbers or planks will not be permitted. Utmost care shall be taken to prevent damage to the bituminous coating. Any exposed metal or damaged coating not exceeding 60 in^5 (40 000 mm^2) shall be covered with an approved bituminous material properly built up, before placing the backfill. Pipe with damaged areas exceeding 60 in^5 (40 000 mm^2) may be rejected.

The pipe shall be bedded according to Section 612.

Pipes of large diameter shall be strutted if shown on the Plans. The struts shall be placed before the embankment is placed and shall be removed when ordered.

Where the pipe sections are joined on the Project, the ends shall be joined with a standard band, bolted firmly in place.

Any pipe which is not in true alignment or which shows any detrimental settlement after laying, shall be taken up and re-laid.

614.09 Backfill. Placement of backfill shall conform to Section 208. Care shall be taken to avoid striking the pipe with tamping tools.

614.10 Method of Measurement. The quantity of corrugated steel or corrugated aluminum pipe will be measured as the number of linear feet (linear meters) of each type of pipe placed and accepted, measured from end to end of pipe, including structure wall thickness, but excluding structure interior.

In measuring lengths of special manufactured connections, exclusive of coupling bands, each actual linear foot (linear meter) placed will be doubled.

614.11 Basis of Payment. The quantity of corrugated steel or corrugated aluminum pipe will be paid for at the Contract unit price per linear foot (linear meter) for each type of pipe. Price and payment will constitute full compensation for furnishing, hauling, and installing pipe; for all cribbing or foundation treatment necessary to prevent settlement; for all shoring and sheeting; for the replacement of any pipe which is not in true alignment or which shows any detrimental settlement after laying; for coating if required; and for all material, labor, equipment, tools, and incidentals required to complete the work.

For pipe under 24" (600 mm) nominal inside diameter and arch pipe under 24" (600 mm) nominal inside horizontal dimension, the excavation (excluding rock), backfill, and backfilling will be included in the price for this work. For pipe of nominal inside diameter or horizontal dimension 24" (600 mm) and over, payment for excavation and backfill will be in accordance with Section 208. Furnishing of Borrow Type C for pipe of nominal inside diameter or horizontal dimension of 24" (600 mm) and over, will be paid for under Section 210.

Payment for excavation and replacement of unsuitable material encountered below the flow line of pipe will be provided for under Section 208.

SECTIONS 615 and 616 RESERVED

SECTION 617 FLARED END SECTION

617.01 Description. This work consists of furnishing and placing corrugated metal pipe and reinforced concrete flared end sections.

617.02 Materials. Materials shall conform to the requirements of Sections 612 and 614, as applicable.

617.03 Construction Methods. Flared end sections shall be placed in conformance with the details, dimensions, and notes shown on the standard sheet and at the locations shown on the Plans.

617.04 Method of Measurement. The quantity of flared end sections will be measured as the actual number placed and accepted.

617.05 Basis of Payment. The quantity of flared end sections will be paid for at the Contract unit price per each. Price and payment will constitute full compensation for furnishing, hauling, and installing materials, including bar reinforcement; for excavating, backfilling, and compacting; for cribbing, shoring, sheeting, coating, and paving; and for all labor, equipment, tools, and incidentals required to complete the work.

SECTION 618 PILE MATERIALS

618.01 Description. This work consists of furnishing treated and untreated timber piles and test piles, cast-in-place concrete piles and test piles, steel H pile and test piles, and precast, pre-stressed concrete piles and test piles.

TIMBER PILE MATERIALS.

618.02 Classification. Untreated timber piles that will be below water level at all times, may be of any species of wood that satisfactorily withstands driving.

Untreated timber piles for use in exposed work shall have a diameter of heartwood at the butt not less than 80% of the required diameter of the pile.

Treated timber piles shall be of southern yellow pine or Douglas fir, unless otherwise specified.

618.03 Requirements. The following requirements shall apply to both untreated and treated timber piles except that piles intended for treating shall be cleaned of all bark and shall be otherwise conditioned as outlined in Subsection 618.04.

All piling shall be cut from sound, live timber and shall contain no unsound knots. Sound knots will be allowed provided the diameter of the knot does not exceed the lesser of 4" (100 mm) or one-third the diameter of the pile at the point where the knot occurs. Any defect or combination of defects, which impairs the strength of the pile more than that of the maximum allowable knot, shall not be permitted. The butts shall be sawed square, and the tips shall be sawed square or tapered to a point not less than 4" (100 mm) square where soil conditions warrant pointing the tip. The slope of the spiral grain, if present, shall not exceed 1" (25 mm) in height for 12" (300 mm) in length.

Piles shall have a uniform taper from butt to tip. A line drawn from the center of the butt to the center of the tip shall not fall outside the center of the pile at any point more than 0.5% of the length of the pile. Bends which cause difficulty in driving are sufficient cause for rejection of the piling.

The piles shall be free from season checks which penetrate more than one-sixth of the diameter of the pile or are more than 3" (6 mm) in width. A check is defined as a lengthwise separation of the wood across the rings of normal growth, extending from the surface toward the pith, but not extending through the piece. Piles must meet the requirements of AASHTO M 168.

618.04 Preparation. Untreated piles shall have the outer bark removed.

Treated piles shall be peeled by removing all the outer bark and at least 80% of the inner bark. No strip of inner bark remaining on the pile shall be over 3/4" (20 mm) wide or over 8" (200 mm) long, and there shall be at least 1" (25 mm) of clean wood surface between any two such strips.

618.05 Dimensions. The diameter that designates the size of piles shall be measured 3' (900 mm) from the butt. The minimum tip diameter of piles shall be 8" (200 mm) for piles under 40' (12 m) in length and 7" (175 mm) for 40' (12 m) and longer piles. All measurements shall be made under the bark. The maximum diameter at butt of any pile shall not exceed 20" (500 mm).

618.06 Preservation Treatment. Treated piles shall receive preservative treatment in accordance with AASHTO M 133 and the AWPA preservation standards specified therein. Unless otherwise specified, the preservative shall be either creosote oil-tar or CCA. The treatment shall be in accordance Table 618-A.

Table 618-A

Preservation Treatment of Timber Piles

Preservative	*Process*	*Retention Rate, lb/ft; (kg/m^3) (land, freshwater, and foundation piles)*	
		Southern Pine	*Douglas Fir*
Creosote Oil-Tar	empty-cell	12 (190)	17 (270)
CCA	full-cell or modified full-cell	0.8 (13)	1.0 (16)
Preservative	*Process*	*Retention Rate, lb/ft; (kg/m^3) (marine piles)*	
		Southern Pine	*Douglas Fir*
Creosote Oil-Tar	empty-cell	20 (320)	20 (320)
CCA	full-cell or modified full-cell	2.5 (40)	NR

NR - not recommended

618.07 Inspection. The timber, and the operation of treatment, will be inspected at the treating plant, both before and after treating, and all acceptable timber will be marked with the Department's standard hammer mark. All timber piles shall also be subject to inspection at the site of the work. If the pile is found defective, it shall be subject to rejection.

618.08 Handling. The methods of storing and handling shall be such as to avoid injury to the piles and shall be approved. Special care shall be taken to avoid breaking the surface of treated piles; canthooks, dogs, or pikepoles shall not be used. All cuts, holes, and injuries of the surface of treated material shall be field-protected by brushing, spraying, dipping, soaking, or coating. Care shall be taken to ensure that all injuries, such as abrasions and nail and spike holes, are thoroughly saturated with the field-treating solution. Treated piles shall not be cut or trimmed in any manner after they are driven other than to saw off the tops as hereinafter specified.

Holes bored in pressure treated material shall be poured full of preservative. Horizontal holes, such as those for sway brace bolts, may be filled by pouring the preservative into them with a bent funnel. All holes made for determining penetration and retention of preservatives shall be filled with tight fitting treated cylindrical plugs.

CAST-IN-PLACE CONCRETE PILE MATERIALS.

618.09 Shells (Steel Casings). The Contractor shall use fluted steel pile shells for cast-in-place concrete piles, unless steel pipe pile shells are specified on the Plans.

If steel pipe piles are used, the steel pipe pile shell shall conform to the requirements of ASTM A 252, Grade 2 with a minimum wall thickness of 3" (6 mm). For welded pipe piles, all seams shall be straight or spiral-butt welded having full strength welded joints. Seamless steel pipe piles are also acceptable. All piles shall be equipped with cast steel, inside-flange, extra strong, ribbed 60 degree conical points. These conical points shall be securely fitted to the bottom of the pile shells by welding with a 30 degree beveled groove weld all around and in such a manner to minimize any extrusion beyond the outside surface of the steel casings. A maximum protrusion of 3" (6 mm) is permissible. If the protrusion exceeds 3" (6 mm), the Contractor shall grind the protruding weld flush with the outside surface of the pile shell.

If fluted steel pile shells are used, the tapered section shall have a tip diameter of 8" (200 mm) with a closed conical point and tapering at the rate of 0.4"/ft (33 mm/m). The fluted steel pile shall be closed or open ended as specified on the Plans. The Contractor shall accomplish splices by cutting the walls in a serrated pattern, inserting the added section, crimping back,

and welding along the entire perimeter with a continuous 3/8" (10 mm) fillet weld. All welding shall be performed by AWS certified welders approved by the Department. Welding certifications shall be current and must show passing qualifications for the type of welding to be performed. The steel for the shells shall conform to SAE 1010 or 1015 and have a minimum yield point of 50,000 psi (345 MPa) and a minimum thickness of 7 gage (4.55 mm).

All field splices shall have the full strength of the sections they connect and require approval of the Engineer. Generally the minimum distance between field splices on the pile shall be 40' (12 m).

618.10 Protective Coating. When indicated on the Plans, the pile shells (steel casings) shall be protected with a coating consisting of either coal tar epoxy or fusion bonded epoxy.

If coal tar epoxy coating is specified, two coats of dark red coal tar epoxy shall be applied. The pile shell shall be thoroughly dry and commercially blast cleaned according to SSPC-SP 6 before coating. The two coat application, final drying time, touch-up, and inspection shall conform to the specifications of the SSPC. The dry film thickness of each coat shall be 8 mils (200 µm) minimum and 16 mils (400 µm) for the two-coat system.

If fusion bonded epoxy coating is specified, it shall be a one-part, heat curable, thermosetting powder coating meeting the following requirements:

Property	***Test Method***	***Value***
Gloss 60 degrees	ASTM D 523	25 to 90%
Impact (5/8" Top) [16 mm Top]	ASTM G 14	80-160 Inch Pounds (9 to 18 J)
Taber Abrasion*	ASTM D 4060	70 mg/1000 cycles
Chemical Resistance	ASTM D 1308	10% CaCl No Effect 10% NaOH No Effect Sat $Ca(OH)_2$ No Effect
Color	Red Standard (For other colors, consult coater.)	

* Taber Abrasion run CF 10 wheel, 1000 g load, 1000 cycles

The fusion bonded epoxy coating shall be applied in an environmentally controlled plant that is fully enclosed. The blast cleaning apparatus and the coating application system shall be approved and pre-qualified by the Department. All surfaces to be coated shall be blast cleaned according to SSPC-SP 5 "White Metal Blast Cleaning" standards. The blast profile shall be 2 to 3 mils (50 to 75 µm). The coating shall be applied within eight hours after blast cleaning. The coating shall be applied as an electrostatically charged dry powder sprayed onto the grounded pile. The coating shall be heated and cured in accordance with the manufacturer's recommended procedures to provide a fully cured finish. The coating shall be applied to a cured thickness of 25"2 mils (635 " 50 µm) as tested in accordance with ASTM G 12.

For both the coal tar and fusion bonded epoxy coatings, a compatible touch-up compound shall be provided for repairing areas damaged during driving. The touch-up compound shall be applied by the Contractor to all visible open areas in accordance with the manufacturer's recommended procedures.

The length of each pile to be coated shall be in accordance with the requirements noted on the Plans. Test piles shall also be coated if a protective coating is specified for the production piles in the group.

618.11 Portland Cement Concrete. Portland cement concrete shall conform to the requirements of Section 812, Class B.

618.12 Bar Reinforcement. Bar reinforcement shall conform to the requirements of Section 824.

618.13 Storage and Handling. The pile casings or shells shall be carefully stored and protected to avoid dents, abrasions, and other injuries and shall be picked up in a manner that will avoid bending and distortion. If the pile shells are damaged due to improper storage or handling, they shall be rejected

618.14 Inspection. Shells (steel casings) will be inspected by the Department at the point of shipment prior to applying any protective coating. If a protective coating is required, the application of the protective coating will be inspected at the plant. The pile shells shall also be subject to inspection at the Project site prior to driving. All defective piles will be rejected.

STEEL H PILE MATERIALS.

618.15 Materials. Unless otherwise indicated, all steel H piles shall conform to the requirements of AASHTO M 183/M 183M. Materials for splices or reinforced tips shall be the same as the H pile except that cast steel may be used for tips. All welding and welding materials shall be as specified under Subsection 826.12. Steel shall be straight and true with the camber and sweep within the permissible mill tolerances.

PRECAST, PRESTRESSED CONCRETE PILE MATERIALS.

618.16 Portland Cement Concrete. Portland cement concrete for square pre-stressed concrete piles shall conform to the requirements of Sections 623 and 812 as amended herein, and f'_c shall be 6,000 psi (40 MPa), unless noted otherwise on the Plans. The Contractor shall develop its own concrete mix design, according to the requirements of ACI 211.1, which shall be submitted to the Engineer for approval. The cement content shall not be less than 658 lb/yd; (390 kg/m^3). Portland cement shall conform to the requirements of AASHTO M 85, Type II.

With the approval of the Engineer, a blend of Type I cement conforming to the requirements of AASHTO M 85 and ground granulated blast-furnace slag cement conforming to the requirements of ASTM C 989, Grade 120 may be used in lieu of the specified minimum amount of Type II cement. The slag cement percentage shall be not less than 35% nor greater than 50% of the Type I-slag cement blend by weight.

618.17 Pre-stressing Strands. Pre-stressing strands shall be seven-wire stress relieved, strands conforming to the requirements of AASHTO M 203/M 203M, Grade 270, unless noted otherwise on the Plans. The pre-stressing strands shall be arranged and stressed as shown on the Plans.

618.18 Spiral Reinforcing. Spiral reinforcing shall conform to the requirements of AASHTO M 32/M 32M.

618.19 Bar Reinforcement. Bar reinforcement, if required, shall conform to the requirements of Section 824, Grade 60 (Grade 420).

618.20 Fabrication. The pre-stressed concrete piles shall be manufactured in accordance with the requirements of Section 623.

Working drawings of the pile fabrication details shall be submitted in accordance with Subsection 105.04. Piles shall be furnished with flat tips as shown on the Plans. Pointed pile tips shall not be used, unless specifically called for on the Plans.

Tolerance for pre-stressed concrete piles shall be as follows:

Width:	-3" (-6 mm) to +1" (25 mm)
Head Out of Square:	3" (6 mm) per 12' (300 mm) of width, measured diagonally
Horizontal Alignment: (Deviation from straight line parallel to centerline of pile)	1/8" (3 mm) per 10' (3 m) of pile
Position of Stirrup Bars and Spirals:	+3/4" (+19 mm), maintain specified clearance
Position of Tendons:	"3" ("6 mm)
Position of Handling Devices:	"6" ("150 mm)

618.21 Storage and Handling. The piles shall be stored, protected, and handled properly to avoid damage. Slings or other appropriate rigging shall be used at the designated pick up points to avoid damage to the piles. If the piles are damaged due to improper storage or handling by the Contractor, the piles will be rejected and shall be replaced by the Contractor.

The Contractor shall submit working drawings to the Engineer for review showing the procedures for picking up, transporting, and handling the piles prior to handling the piles. Piles may be moved after transfer of the pre-stressing force. Piles may be driven after the concrete has aged at least seven days and the concrete compressive strength is equal to or greater than the specified 28-day compressive strength.

618.22 Method of Measurement. The quantity of permanent timber, cast-in-place concrete, steel H, and precast, pre-stressed concrete piles will be field measured as the total number of linear feet (linear meters) of material ordered as determined by the Department based on test pile driving. The quantity of timber, cast-in-place concrete, steel H, and precast, pre-stressed concrete test piles will be field measured as the total number of linear feet (linear meters) ordered by the Contractor after approval by the Engineer for each type of test pile. The quantity of pile material used in pile splices of all types of piles will be field measured as the total number of linear feet (linear meters) of material furnished to the site as agreed by the Department. Pay measurements will be taken, in every case, before actual driving has begun. The additional length of pile formed and constructed for the purposes of a pile build up for a Precast, Prestressed Concrete Pile will be field measured as the total number of linear feet (linear meters) formed and poured.

618.23 Basis of Payment. The quantity of permanent timber, cast-in-place concrete, steel H, and precast, pre-stressed concrete piles will be paid for at the Contract unit price per linear foot (linear meter) for each type of pile. The quantity of timber, cast-in-place concrete, steel H, and precast, pre-stressed concrete test piles will be paid for at the Contract unit price per linear foot (linear meter) for each type of test pile. The quantity of pile material used for pile splices will be paid for at the Contract unit price per linear foot (linear meter) for each type of pile. The quantity of pile build ups constructed will be paid at the Contract unit price per linear foot (linear meter) for precast, pre-stressed concrete piles.

Price and payment will constitute full compensation for furnishing all pile and test pile materials, including pile tip, preservatives for timber piles, metal pile shells, protective coating for piles, bar and spiral reinforcement, pre-stressing strands, dowels for precast piles, Portland cement concrete for cast-in-place piles, costs associated with construction of pile build ups, and for all labor, equipment, tools, and incidentals required to complete the work.

All piles that are damaged due to improper storage or handling by the Contractor shall be replaced by the Contractor at no expense to the Department.

No payment will be made for production piles and test piles not accepted, production piles and test piles improperly driven, or production piles and test piles damaged during driving.

The installation of timber, cast-in-place, steel H, and precast, pre-stressed concrete piles and test piles will be paid for under Section 619.

Labor costs associated with splicing precast, pre-stressed concrete piles to obtain proper length will be paid for under Section 619.

SECTION 619 INSTALLATION OF PILES

619.01 Description. This work consists of installing four types of production and test piles. The four types of piles are timber, cast-in-place concrete, steel H, and precast, pre-stressed concrete. This work also consists of extracting, removing, and disposing of any test pile where required.

619.02 General. All materials used in the installation of any production or test pile shall conform to the requirements of Section 618. The location of production and test piles shall be as shown on the Plans or as directed by the Engineer.

No piles shall be driven until all excavating and backfilling necessary at any structural unit have been completed. No production piles shall be driven until the test pile or piles have been driven and the results have been evaluated by the Engineer.

Pile and Pile Driving Equipment Data	
Contract No.:	County:
Project:	
Structure Name and/or No.:	
Pile Driving Contractor or Subcontractor:	
(Piles driven by)	
Hammer	Manufacturer: Model: Type: Serial No.:| Rated Energy: @ Length of Stroke Modifications:
Capblock	Material: Thickness: Area: Modulus of Elasticity - E: psi (MPa) Coefficient of Restitution - e:
Pile Cap	Helmet Bonnet - Weight: Anvil Block Drivehead
Cushion	Cushion Material: Thickness: Area: Modulus of Elasticity - E: psi (MPa) Coefficient of Restitution - e:
Pile	Pile Type: Length (in Leads): Weight/meter: Wall Thickness: Taper: Cross-Sectional Area: in5 (mm^2) Design Pile Capacity: tons (metric tons) Description of Splice: Tip Treatment Description:
Submitted By:	Date:

Production and test piles shall be driven to one or a combination of the following criteria as directed by the Engineer:

Driven Bearing

Tip Elevation

Practical Refusal

Bearing Achieved by Freeze

EQUIPMENT.

619.03 Driving Hammers. All piles shall be driven with a steam, air, or diesel hammer. The minimum rated energy of the pile driving hammer per blow shall meet the following requirements:

Timber production and test piles	12,000 ft.lb (16.3 kJ)
Cast-in-place concrete production and test piles	16,000 ft.lb (21.7 kJ)
Precast, Pre-stressed concrete production and test piles	29,500 ft.lb (40.0 kJ)
Steel H production and test piles	22,400 ft.lb (30.4 kJ)

For steel H production and test piles, a driving head, grooved to the cross-section of the pile, shall be used to prevent damage to the tops of piles.

For production and test piles, pile hammers shall be sized to ensure that stresses associated with hammer impact do not exceed allowable driving stresses specified in Subsection 619.09. In the case of batter piles, the wave equation analysis shall also consider the decrease in energy due to the inclination of the pile driving hammer.

The pile hammer shall be maintained in proper adjustment consistent with the manufacturer's recommendations. The pile hammer shall be operated at the manufacturer's rated number of blows per minute and at the rated steam or air pressure for steam and air hammers. For steam or air hammers, the Contractor shall furnish a boiler or air compressor with a capacity at least equal to that specified by the manufacturer of the hammer to be used, and the Contractor shall equip the boiler or compressor with an accurate pressure gage. Double acting diesel hammers shall be equipped with either a pressure gage or other device calibrated in a manner that enables the Engineer to determine hammer energy. The device and calibration curves shall be as recommended by the hammer manufacturer and shall be submitted to the Engineer for review and approval. Single acting hammers of all types shall be equipped to allow accurate visual monitoring of the stroke height by the Engineer. The mechanism providing such stroke height monitoring shall be submitted to the Engineer for review and approved prior to driving the initial test pile on the Project.

The Contractor shall furnish to the Engineer for approval information regarding the proposed pile driving system on the form, "Pile and Pile Driving Equipment Data".Pile driving equipment shall not be transported to the Project site until such approval is granted.

The hammer, hammer cushion, and pile cushion used to drive the production and test piles shall be the same type and size as those used in the wave equation analysis. No modifications or substitutions will be permitted without the approval of the Engineer.
Approval of a pile hammer shall not relieve the Contractor of responsibility for achieving the required bearing, piles damaged because of misalignment of the leads, failure of capblock or cushion material, failure of splices, malfunctioning of the pile hammer, or other improper construction methods. Piles damaged for such reasons will be rejected and shall be replaced by the Contractor if the Engineer determines that the damage impairs the strength or the serviceability of the pile.

619.04 Driving Helmet and Pile Cushion. A driving helmet, including a pile cushion for concrete piles, shall be used between the top of the pile and the ram to prevent impact damage to the piles. The driving helmet, and pile cushion for concrete piles, shall be capable of protecting the head of the pile, minimizing energy absorption and dissipation, and transferring hammer energy uniformly over the top of the pile. The driving helmet shall fit loosely around the top of the pile, so that the pile is not restrained by the driving helmet if the pile tends to rotate during driving. The pile cushion may be of solid wood or of laminated construction, shall completely cover the top surface of the pile, and shall be retained by the driving helmet. The minimum thickness of the pile cushion shall be 6" (150 mm), and the thickness shall be increased so as to be suitable for the size and length of pile, character of subsurface materials to be encountered, and hammer characteristics. The exact size and characteristics of the pile cushion shall be determined from the wave equation analysis. Timber or timber product pile cushion if used shall be replaced if it becomes compressed to 50% of its original thickness, if it becomes charred or burned, or if it becomes deteriorated in any manner during driving. If the Contractor opts to use another type of pile cushion, its properties and replacement criteria shall be submitted for approval with the wave equation analysis.

619.05 Leads. All piles shall be supported in line and position with leads while being driven. Pile driver leads shall be constructed in a manner that affords freedom of movement of the hammer, while maintaining alignment of the hammer and the pile to ensure concentric impact for each blow. Leads may be either fixed or swing type. Swinging leads, when used, shall be fitted with a pile gate at the bottom of the lead, and in the case of batter piles, a horizontal brace shall be required between the crane and the leads. The leads shall be adequately embedded in the ground. Alternatively, for battered piles, the pile shall be constrained and the leads anchored in a structural frame such as a template, as approved by the Engineer, to maintain batter and alignment of the driven piles. The leads shall be of sufficient length to make the use of a follower

unnecessary and shall be so designed as to permit proper placement of batter piles. The leads and crane shall have the ability to handle, as a minimum, piles of the length indicated on the Plans plus 10' (3 m).

619.06 Followers. Followers shall only be used when approved in writing by the Engineer, or when specifically stated in the Contract. In cases where a follower is permitted, the first pile in each bent and every tenth pile driven thereafter shall be driven full length without the use of a follower to determine that the desired bearing capacity is being attained. The follower and pile shall be held and maintained in equal and proper alignment during driving. The follower shall be of such material and dimensions to permit the piles to be driven to the length determined necessary from the driving of the full length piles. The final position and alignment of the first two piles installed with followers in each substructure unit shall be verified to be in accordance with specified location tolerances before additional piles are installed.

619.07 Water Jets. Water jets will not be permitted unless approved in writing by the Engineer or when specifically stated in the Contract. Water jets will not be permitted when installing any steel H piles. The number of jets and the nozzle volume and pressure shall be sufficient to freely erode the material adjacent to the piling. The plant shall have sufficient capacity to deliver at all times a pressure equivalent to at least 100 psi (700 kPa) at two 3/4'' (19 mm) jet nozzles. To determine driving resistance, all piles shall be driven the last 3 feet (meter) without the aid of jets. The type and configuration of water jets shall be submitted and approved prior to driving the initial test pile on the Contract.

CONSTRUCTION METHODS.

619.08 Preparation for Driving. The heads of the timber production and test piles, when the nature of the driving is such as to injure them unduly, shall be protected by caps of approved design. Collars or bands to protect them against splitting or brooming shall be provided where necessary.

Steel H production and test piles shall be driven in unspliced lengths whenever possible. Splices will only be permitted when specifically approved by the Engineer and shall be held to the absolute minimum. Splicing together short pile cut-offs to form a pile will not be permitted. Splice details will be as shown on the Plans or as approved by the Engineer. When reinforced pile tips are required, they shall be as detailed on the Plans or as approved by the Engineer.

619.09 Bearing Values. The Engineer will determine the driving resistances, tip elevations, and safe bearing capacity as described in this Subsection.

Wave equation analysis will be required for all types of piles discussed in this Section, unless otherwise shown in the Contract.

The Contractor shall be responsible for performing the wave equation analysis, unless otherwise specified, to obtain the relationship between blow count and estimated ultimate capacity. As determined by the Schedule of Work, but no less than 30 calendar days prior to driving the initial test pile, the Contractor shall submit the wave equation analysis, certified by a Professional Engineer registered in Delaware, to the Engineer for review and approval. The wave equation analysis will be used to verify the adequacy of the pile driving system and to establish the necessary blow counts, stroke heights, pile cushions, and any other applicable information for use in driving initial test piles to the required bearing capacity and tip elevation. This criteria may be reevaluated during test pile driving and may or may not be revised for production pile driving.

Along with the wave equation analysis, the Contractor shall submit to the Engineer the necessary pile driving equipment information on the "Pile and Pile Driving Equipment Data" form shown in Subsection 619.03.

Included in the submittal shall be computer input and output sheets and suitable data plots displaying the Contractor's wave equation analysis for the pile driving throughout the various subsurface conditions of the site. The plots shall show ultimate resistance versus blow count as well as maximum tension and compression stresses versus ultimate resistance. Unless otherwise specified on the Plans, a safety factor of 2.5 shall be used to calculate the allowable bearing capacity and a safety factor of 2 shall be used for bridges with pile load tests.

The information relating to the pile driving equipment proposed by the Contractor for the Project must be used as input to perform the wave equation analysis. If the wave equation analysis shows that the pile may be damaged at any time during driving, or if it is not possible to drive the pile to the desired ultimate capacity due to the proposed equipment or methods, the Contractor shall modify its proposed methods or equipment until a subsequent wave equation analysis indicates that the piles can be driven to the desired ultimate capacity, without damage.

During pile driving operations, the Contractor must use the approved equipment. No variations in the driving system will be allowed, unless the Contractor performs a revised wave equation analysis which is approved in writing by the Engineer.

A wave equation analysis must be performed for test piles at each abutment and pier location unless otherwise specified on the Plans. The wave equation analysis should evaluate drivability of the pile to various depths of penetration using the proposed driving system. As a minimum, the driving conditions for 5% penetrations (or an alternate depth of penetration as determined by the Engineer), 70% penetration, 90% penetration, 100% penetration, and 110% penetration of the pile during initial driving and after set-up condition should be evaluated. One hundred percent penetration refers to penetration to the plan estimated tip elevation to achieve the designated ultimate driven capacity. If the Contractor's estimate of tip elevation for the ultimate driven capacity differs from the plan estimate by more than 10%, then the Contractor's estimate of penetration shall be used for 100% penetration in the wave equation analysis. If the Contractor's estimate is chosen as 100% penetration, then driving conditions for plan estimated depth shall also be shown in the analysis

In the drivability analysis, the estimated friction and end bearing values obtained by static soil analysis along with soil layer specific quake and damping values and friction parameters for each level of penetration shall be used. Analysis output shall include, as a minimum, ultimate capacities, blow counts, compressive and tensile stresses, and transferred energy plotted as a function of depth of penetration. The static soil analysis must be submitted with the wave equation analysis.

If the Contractor's driving equipment consists of a varying energy or varying stroke type hammer, such as an open-ended diesel hammer, then an additional analysis that plots blow count versus stroke and/or energy for a fixed capacity equal to the ultimate driven capacity shall be performed.

The Contractor shall select a hammer that drives the pile to its required penetration to achieve required bearing or minimum tip elevation with a driving resistance not exceeding 120 blows per 12" (300 mm). In no case shall the driving resistance exceed 20 blows per 1" (25 mm) in the last 6" (150 mm) of penetration

Unless buckling governs or unless otherwise noted in the Plans or Special Provisions, pile driving stress, due to hammer impact only, shall be limited to the values, in megapascals, specified below:

1. *Timber Piles:*

Tension or Compression	$3\sigma_a$ (where σ_a = AASHTO allowable working stress for round timber pile

2.
3. *Steel H Piles, Steel Pipe Piles, and Steel Shell Piles (Cast-In-Place Concrete Piles):*

Tension or Compression	$0.9\ f_y$

4.
5. *Precast, Prestressed Concrete Piles:*

Tension	0.25 (square root of $f\ N_c$) + effective pre-stress
Compression	$0.85\ f\ N_c$ - effective pre-stress

If the test pile driving data or pile load test results indicate that a higher pile load capacity is possible, the Department reserves the right to redesign the pile layout, and footing if necessary, for the higher pile capacity as long as the capacity can be obtained by use of the same hammer.

For batter piles, the safe bearing capacity of the pile along its axis shall be equal to "U" times "P". The value of "U" for steam or air hammers and diesel hammers shall be determined as follows:

seq Equation * Arabic \h

where: U =A coefficient, less than unity.

P = Safe allowable bearing capacity of piles, in pounds (kilograms), when driven vertically.

m = Tangent of the angle of batter.

If required by the Contract, the Engineer will perform dynamic monitoring of the driving of piles. This monitoring will provide information for determining the necessary production pile driving guidelines.

619.10 Pile Load Test. When required in the Special Provisions or when directed by the Engineer, safe bearing capacities of piles shall be determined by actual load tests. All requirements shall be in accordance with the Special Provision items indicated on the Plans.

619.11 Test Piles. When driving test piles, the following step-by-step procedures shall be followed:

a. *Driving Test Piles to Bearing, Tip Elevation, Practical Refusal, or a Combination of These.*

1. Perform the wave equation analysis based on the procedure outlined in Subsection 619.09.
2. Ensure that test piles are the initial piles driven, are in general plumb piles, and that they meet the following requirements:

a. *Timber Test Piles.* Timber test piles shall be of the same material and size as the production piles, except that if treated timber production piles are specified, untreated test piles may be used if the Engineer gives written permission and if test piles are not to be driven in a permanent location or within any footing area.

Test piles driven outside permanent foundation locations shall, upon satisfactory completion of test driving, be either completely extracted and removed from their present locations or cut off in accordance with the requirements of Subsection 619.16.

b. *Cast-In-Place Concrete; Steel H; and Precast, Prestressed Concrete Test Piles.* Test piles shall be of the same material and size as that specified for production piles. The test piles shall be installed at locations indicated on the Plans. The test piles shall be driven in production pile locations so they can be used in the permanent structure if found satisfactory after testing. Bar reinforcement and concrete fill shall not be placed until conclusion of the testing and acceptance of the test pile for use as a production pile.3

The Contractor shall furnish the Engineer with schedules of the proposed driving sequence. Driving of test piles shall not be started at any location until the schedule for that location has been approved by the Engineer. Departures from these schedules shall not be made without the Engineer's approval.

The Contractor shall at all times conduct the test pile driving operations in close cooperation with the Engineer or the Engineer's representative. The Engineer or the Engineer's representative, without relieving the Contractor of any responsibility whatsoever, will be present when the test pile driving work is in progress. A complete driving log will be recorded by the Engineer or the Engineer's representative for each test pile driven. The driving log will list all data which is essential for the determination of correct bearing capacity. The Contractor shall conduct test pile driving operations so that all essential measurements and data can be accurately obtained.

3. If one or more static load test is required, the Contractor shall perform at least one of the load tests in the first series of test piles driven.

4. Lengths of test piles shall be as indicated on the Plans. However, should the Contractor's static analysis predict a need for alternate test pile lengths, then the lengths of test piles shall be clearly indicated in the wave equation analysis submittal. After evaluating the wave equation analysis, the Engineer will then issue an order length for test piles. A letter to the Contractor from the Engineer confirming test pile lengths must be received prior to the Contractor ordering any test piles.

5. Furnish test piles in one length, and drive them continuously to the required bearing capacity and/or tip elevation.

6. Assist the Engineer with dynamic pile testing in accordance with Special Provision 621502.

7. The Engineer will advise the Contractor when test pile driving shall cease. However, in no case shall the pile be driven to exceed 240 blows per 12" (300 mm) or 20 blows per 1" (25 mm) of driving for a minimum of 3" (75 mm).

8. Any pile damaged by reason of internal defects or improper driving and any pile, as indicated below, driven out of its proper location or alignment shall be removed and replaced. Any driven timber pile that shows evidence of splitting, splintering, or brooming shall be removed and replaced. Any driven shell or casing that shows bends, kinks, or other deformations which are detrimental to its use as a production pile shall be removed and replaced. As an option, a second pile may be driven adjacent to the damaged or mislocated pile if the second pile can be driven without detriment to the structure and if approved by the Engineer.

   The Contractor shall provide all facilities so that the required records will be kept of the pile lengths, hammer speeds, blows per foot (meter), tip elevations, and other pertinent data for all piles driven. The Contractor shall also clearly mark the pile in 12" (300 mm) increments to assist in evaluating the driving. The mark shall be visible from a 55' (17 m) distance.

   Piles shall be driven within an allowed variation of 1/8" (3 mm) per 12" (300 mm) of pile length from the vertical or batter shown on the Plans. The maximum allowable variation at the top of the pile shall be 3" (75 mm) in any direction from the location shown on the Plans.

   No side pressure will be permitted for driving piles into the correct position.

9. Following the driving of the test pile or series of initial test piles as agreed in the approved sequence of driving, the Engineer will review the driving records and make one of the following recommendations:

   a. If load tests are not required, the Engineer will issue, within five working days after completion of the test pile driving, a list of production pile lengths to the Contractor for those piles governed by the test pile or group of test piles.

   b. If the data and information obtained from driving any original test pile is conflicting, inconclusive, or unsatisfactory in any way, the Engineer will order, within two working days after completion of the initial driving, another test pile to be driven for additional information.

   c. The Engineer will order, within two working days after completion of the initial driving, a test pile re-strike to be performed in accordance with Subsection 619.14.

   d. The Engineer will order, within two working days after completion of the initial driving, a driving splice to be made on the test pile. The driving splice shall be made in accordance with the driving splice details shown on the Plans. After splicing is successfully completed, driving of the spliced pile shall be continued. When the driving of the spliced pile is completed, the Engineer will review the new driving records and make one of the recommendations listed under Step (9) above.

e. On jobs requiring static load testing, the Engineer may approve the driven test pile for load testing.

Recommendation (9)b., (9)c., or (9)d. above may be chosen prior to authorizing a load test to be performed. Also, recommendation (9)b., (9)c., or (9)d. above may be chosen if a load test is performed and found to be unsatisfactory. After a load test has been successfully completed, the Engineer will issue, within three working days after receipt of the Contractor's load test report, a list of production pile lengths to the Contractor for those piles governed by the test pile or group of test piles.

10. On jobs requiring minimum tip elevation, the Engineer will evaluate the driving records, and in addition to recommendations (9)b. through (9)e. above, the Engineer may direct a revised tip elevation based on the test pile driving record. This revised tip elevation will be included in the issued production pile order list.

11. If a pile reaches driving resistances exceeding 240 blows per 12" (300 mm) or 20 blows per 1" (25 mm) at a tip elevation significantly above the minimum tip elevation specified, the Contractor shall immediately inform the Engineer. The Engineer will analyze the pile group and direct the Contractor to perform corrective measures as required. At this point, the Contractor shall seek other methods, as approved by the Engineer, to drive the pile to the required minimum tip elevation.

12. If any test pile build-ups (non-driving splices) are necessary, build-ups shall be constructed in accordance with the requirements of Subsection 619.15.

13. Cut off the test pile, if necessary, in accordance with the requirements of Subsection 619.16.

14. After driving, pre-stressed concrete piles shall have their tops covered with plastic to prevent dirt and water from entering holes/sleeves provided for grouting in bar reinforcement for anchorage into the pier caps or the abutment footings. Prior to grouting in bar reinforcement, such holes/sleeves shall be blasted out with air to remove any dirt and/or water.

b. *Driving Test Piles to Bearing Achieved by Freeze.*

1. Steps (1) through (8) under (a) above shall be followed.

2. After successful driving of the test pile, the Engineer will order, within two working days after completion of the initial driving, a test pile re-strike to be performed in accordance with the requirements of Subsection 619.14.

3. On jobs requiring static load testing, test pile re-strikes shall be performed in accordance with the requirements of Subsection 619.14.

4. If any test pile build-ups (non-driving splices) are necessary, build-ups shall be constructed in accordance with the requirements of Subsection 619.15.

5. The test pile shall be cut off, if necessary, in accordance with the requirements of Subsection 619.16.

619.12 Driving Production Piles. When driving production piles, the following step-by-step procedure shall be followed:

1. The Engineer will establish the required blow count, stroke height, and tip elevation from the test pile results.

2. The same hammer, cushioning, and other equipment that was used to drive the test piles must be used to drive the production piles. If the Contractor elects to change hammers, the Contractor must submit necessary wave equation analysis, drive additional test piles, and/or perform dynamic pile testing, as directed by the Engineer, before driving any production piles, even if the energy ratings of the hammers are identical.

3. The pile driving sequence shall conform to the requirements established under Subsection 619.11. If necessary, additional detail shall be provided by the Contractor so that the Engineer is fully aware and in agreement with the proposed sequence of driving.
4. Each production pile shall be driven continuously from the time that driving is started until the required bearing capacity and/or tip elevation is reached, except as may be required for splicing the pile.
5. No production piles shall be driven to exceed 240 blows per 12" (300 mm) or 20 blows per 1" (25 mm) for a minimum of 3" (75 mm).
6. Piles shall be driven to such depth that they develop at least the safe bearing capacities that are specified or until they reach practical refusal. The Engineer reserves the right, however, to establish the depth to which any or all piles are to be driven, depending on the actual conditions encountered.
7. Any pile damaged by reason of internal defects or improper driving and any pile, as indicated below, driven out of its proper location or alignment shall be removed and replaced. Any driven timber pile that shows evidence of splitting, splintering, or brooming shall be removed and replaced. Any driven shell or casing that shows bends, kinks, or other deformations which are detrimental to its use as a production pile shall be removed and replaced. As an option, a second pile may be driven adjacent to the damaged or mislocated pile if the second pile can be driven without detriment to the structure and if approved by the Engineer.

   The Contractor shall check piles for heave during driving of adjacent piles or by any other cause. All piles pushed up more than 3" (6 mm) shall be re-driven to the minimum bearing capacity and at least to their original tip elevation, or as directed by the Engineer.

   The Contractor shall provide all facilities so that the required records will be kept of the pile lengths, hammer speeds, blows per foot (meter), tip elevations, and other pertinent data for all piles driven.

   All piles shall be driven at locations shown on the Plans or as directed by the Engineer. Piles shall be driven within an allowed variation of 1/8" (3 mm) per 12" (300 mm) of pile length from the vertical or batter shown on the Plans. The maximum allowable variation at the top of the pile shall be 3" (75 mm) in any direction from the location shown on the Plans.
   No side pressure will be permitted for driving piles into the correct position.

   Any material forced up between the piles during driving shall be removed to the correct elevation before any concrete is placed for the foundation.

   Piles shall be driven to secure the required bearing capacity and/or tip elevation specified herein, noted on the Plans, or specified by the Engineer. After driving of each pile group, the location and alignment of the piles shall be surveyed by the Contractor. The results of the survey shall be furnished to the Engineer. In the event that one or more of the piles are damaged by improper driving, or driven outside the allowable tolerance specified herein, the Engineer will analyze the pile group. If the analysis indicates that any pile is overstressed as a result of the damaged or out of tolerance piles, the Contractor shall remove the rejected pile or drive additional piles as directed by the Engineer. In addition, the Contractor shall modify the pile cap or abutment as required by the Engineer to accommodate the out of tolerance or added piles. All piles damaged by improper driving, or driven out of their proper location or alignment shall be rejected.
8. Any driving splices determined necessary by the Engineer shall be made in accordance with the Plans or other details submitted by the Contractor to the Engineer for review and approval. Following the required curing time for the splice, the spliced pile shall be driven to the required bearing capacity and/or tip elevation. If it becomes necessary to splice timber piles, the method for splicing and driving shall be submitted to the Engineer for written approval.
9. Any build-ups (non-driving splices) shall be constructed in accordance with the requirements of Subsection 619.15.
10. If the piles are driven to a tip elevation, as shown on the Plans or directed by the Engineer, and "Bearing Achieved by Freeze" is being used to achieve the desired bearing, the Engineer may direct the Contractor to re-strike selected production piles in a particular footing, bent, or structural element. If this direction is given, the production pile re-strikes shall be performed in accordance with the requirements of Subsection 619.14.
11. Cut-offs, as necessary, shall be performed in accordance with the requirements of Subsection 619.16.After driving, pre-stressed concrete piles shall have their tops covered with plastic to prevent dirt and water from entering holes/sleeves provided for grouting in bar reinforcement for anchorage into the pier caps or the abutment footings. Prior to grouting in bar reinforcement, such holes/sleeves shall be blasted out with air to remove any dirt and/or water.

619.13 Augering.

a. *General.* When specifically indicated on the Plans or specifically approved by the Engineer, augering shall be used to facilitate pile driving. The Contractor shall submit its proposed equipment and augering procedures to the Engineer for approval prior to beginning pile driving operations.

When round piles are used, the auger diameter shall not be greater than 2" (50 mm) less than the pile diameter. The auger diameters listed below shall be used for square concrete piles unless otherwise shown on the Plans:

PRIVATE *Hole Diameter*	*Pile Size*
10" (250 mm)	12 by 12" (300 by 300 mm)
12" (300 mm)	14 by 14" (350 by 350 mm)
14" (350 mm)	18 by 18" (450 by 450 mm)
20" (500 mm)	24 by 24" (600 by 600 mm)
24" (600 mm)	30 by 30" (750 by 750 mm)
30" (750 mm)	36 by 36" (900 by 900 mm)

For other pile sizes, the diameter of the augers shall be as shown on the Plans, or approved by the Engineer. The pile holes shall be accurately augered with the hole centered over the plan location of the piling. The location and vertical alignment shall be maintained within the tolerances allowed for the piling.

For an augered hole which is required through rock material or a very dense layer that may damage the pile during driving, the augered hole diameter shall be approximately 2" (50 mm) larger than the largest dimensions across the pile's cross-section. When required by the Plans or Project subsurface conditions, the Contractor shall maintain augered holes open both before and during pile driving operations. Bentonite slurry or an equivalent method shall be employed, if necessary, to maintain the holes in an open condition.

b. *Augering Through Compacted Fill.*

1. When steel H or other low displacement piles are used, piles shall be driven through the compacted fill without augering holes through the fill, except when the requirements for augering are shown on the Plans. When concrete or other high displacement piles are used, pile holes shall be augered through the fill to at least the elevation of the original ground surface.

2. For an augered hole which is required through material that caves during driving, to the extent that the auguered hole does not serve its intended purpose, the hole shall be cased from the embankment surface to the approximate elevation of the original ground surface. After the pile is driven, annular spaces between the casing and pile shall be filled with concrete sand or other approved clean sand in a manner approved by the Engineer. Unless otherwise shown on the Plans, the casing shall be removed after the pile is driven and accepted.

   Any voids between the pile and soil remaining after driving through an augered hole, cased or uncased, shall be filled with concrete sand or other approved clean sand in an approved manner. The use of spuds (a spud is a short, strong driven member that is removed to make a hole for inserting a pile) will not be permitted in lieu of augering.

619.14 Pile Re-strike. After initial driving of production and/or test piles, the Engineer may order, within two working days after completion of the initial driving, a pile re-strike. The re-strike shall be performed within seven days of initial driving unless otherwise noted in the Contract. After the directed waiting time has elapsed, the pile re-strike shall be performed as follows:

Dynamic pile testing equipment shall be connected, if indicated on the Plans or directed by the Engineer, in accordance with Special Provision 621502.

1. The pile hammer used during initial driving must be used for the re-strike.

2. The hammer shall be warmed-up by striking another pile or pile cut-off at least 20 blows at full stoke.
3. The elevation of the top of pile shall be established prior to performing the re-strike.
4. The hammer shall be carefully lowered and positioned on the pile. The hammer shall strike the pile 20 blows at the required stroke height.
5. The hammer shall be removed from the pile, and the new top of pile elevation shall be established.
6. After completion of the pile re-strike, the Engineer will review the driving records and make a recommendation, within two working days, on how to proceed.
7. On contracts requiring dynamic pile testing, all piles to receive dynamic pile testing shall be subject to re-strikes as described in Special Provision 621502.

On contracts requiring static load testing, test pile re-strikes shall be performed, on each pile to be load tested, after a minimum of three but before five calendar days after completion of the pile load test. The pile load test shall be performed in accordance with Special Provision 620525, unless directed otherwise by the Engineer.

As directed by the Engineer, up to ten production piles driven shall be subject to pile re-strikes. The Engineer will specify a waiting time of five days or less to perform the pile re-strikes, unless noted otherwise on the Plans.

The Engineer will attempt to schedule the pile re-strikes so as to cause minimal, if any, delay to the overall pile driving operation. If the pile re-strike results are satisfactory, the pile or representative group of piles shall be considered acceptable.

The pile re-strikes described above shall be incidental to the price bid for the selected pile type. Under certain pile driving conditions it may become necessary to re-strike various production piles and/or test piles, in addition to those described above, in order to verify the pile capacities. These additional re-strikes may be a result of needing more than ten production pile re-strikes or the re-strike waiting time required may be greater than that specified above or in Special Provision 621502. Payment for additional pile re-strikes will be as described in Special Provisions 620528 and 620529.

619.15 Pile Build-Ups. All build-ups shall be constructed as shown on the Plans or on other details submitted by the Contractor for review and approval by the Engineer.

619.16 Pile Cut Offs. Piles shall be cut to final cut-off elevation shown on the Plans or as directed by the Engineer. Cut-off sections of piles shall become the property of the Contractor at the end of the Project and shall be disposed of by the Contractor in a manner acceptable to the Engineer.

Pile shells or casings, after being driven, inspected, and approved, shall be cut off to a true plane using an acetylene or electric torch.

The tops of all timber production piles shall be sawed to a true plane at the elevation shown on the Plans, or as directed by the Engineer. Piles which support timber caps or grillage shall be sawed to conform to the plane of the bottom of the superimposed structure.

All exposed sawed surfaces of timber piles shall be thoroughly brush coated with three applications of preservative and covered with a thick layer of hot pitch or gum. Upon this shall be placed a metal covering of either a sheet of zinc or copper. Zinc sheet conforming to ASTM B 69 shall be at least 20 gage (813 Fm) thick and shall be fastened with 1" (24 mm) long galvanized large-headed nails. Copper sheet conforming to AASHTO M 138 (M 138M) shall be at least 20 gage (813 Fm) thick and shall be fastened with 1" (25 mm) copper nails. The metal covering shall measure at least 4" (100 mm) more in each dimension than the diameter of the pile and shall be bent down over the sides of the pile, neatly trimmed, and securely nailed to the full satisfaction of the Engineer.

Test piles driven outside permanent foundation locations shall, upon satisfactory completion of test driving, be cut off at a point at least 24" (600 mm) below finished grade or final stream bed elevation at their respective locations.

619.17 Placing Bar Reinforcement for Cast-In-Place Concrete Piles. The longitudinal bar reinforcement and circular ties shall be assembled as a complete unit. The bars and ties shall be securely fastened together at all intersections in accordance with the details shown on the Plans. The complete unit shall be accurately placed in the driven casing or shell and held rigidly in place to prevent displacement during the placing of the concrete.

The Contractor shall submit a drawing or plan, showing the proposed method of holding the bar reinforcement in position during the placing of the concrete. Approval of the method submitted will not relieve the Contractor of its responsibility for ensuring that all bar reinforcement is properly located within the body of the finished piles.

619.18 Placing Concrete for Cast-In-Place Concrete Piles. No concrete shall be placed in any pile casing or shell until all driving within a radius of 15' (5 m) has been completed, or until all of the shells for that structure unit, such as a pier, bent, or abutment, have been driven to their final tip elevation and accepted. In the event that this limitation cannot be followed, all driving within the above limits shall be discontinued until the placed concrete has set for at least seven days.

After driving and completing the pile and other parts of the structure, the exposed part of the piling shall be cleaned of undue discoloration caused by methods of construction.

No concrete shall be deposited in a driven casing or shell until all water, dirt, and debris have been completely removed, and the Engineer has given approval.

Concrete for each shell or casing shall be placed in a continuous operation. An exception will be made if the bar reinforcement caging or dowels occupy only the upper section of the pile. In this case, no bar reinforcement shall be placed in the pile casing or shell until the concrete placed in the casing has reached the elevation of the lowest end of the bar reinforcement. The bar reinforcement shall then be rigidly set in the casing, and the placing of concrete shall be continued until the cut-off elevation has been reached. In no case shall an interruption in the sequence of placing concrete exceed 30 minutes. In the case where bar reinforcement caging or dowels occupy only the upper section of the pile, the Contractor may secure the reinforcement prior to placing any concrete if an "elephant trunk" is used to deposit concrete in the portion of the pile below the bottom elevation of the reinforcement. Concrete shall be consolidated as specified in Subsection 602.13 to a depth of at least 12'' (300 mm) below the bottom of the rebar cage.

The concrete shall be placed in such a manner as to ensure a dense, homogenous mass throughout the entire casing that is completely free from debris, oil, water, and other foreign matters to provide a permanent bond with all bar reinforcement embedded in the pile.

Piles with freshly placed concrete shall not be disturbed in any way until all concrete has set for at least 72 hours.

619.19 Method of Measurement. The installed quantity of test piles and production piles will be field measured as the total number of linear feet (linear meters) from final tip elevation to final cut-off elevation for each type of pile acceptably driven.

The quantity of build-up lengths will not be measured and paid under this Section but will be measured and paid under Section 618.

The quantity of material used for driving splices on test piles and production piles will not be measured and paid under this Section but will be measured and paid under Section 618.

The cost of constructing driving splices for Precast, Prestressed Concrete Piles will be measured on an equivalent linear foot (linear meter) basis. The cost of constructing driving splices for all other pile types will not be measured and paid.

The quantity of pile cut-offs for all pile types will not be measured for payment.